Frequency Range	Maximum Allowable Level	Average Allowable Level*
Above 54 MHz up to and including 300 MHz	-26 dBmV	n/a
Above 300 Mhz up to and including 450 MHz	-20 dBmV	n/a
Above 450 MHz up to and including 1,002 MHz	-15 dBmV	-20 dBmV

*Averaged from measurements on six channels spaced approximately equally in frequency.

3.22 Discussion: With conventional 45 MHz intermediate frequencies (IF), the local oscillator (LO) of a receiver will fall within the passband of another television channel. Given the finite isolation between subscribers connected to multi-taps on cable systems, if that LO signal is transmitted out of the input terminals of one receiver with sufficient amplitude it will interfere with the reception of a subscriber connected to another tap port and tuned to a program seven channels above the interfering receiver. In the worst case situation in which a desired channel is received at the Part 76 minimum allowable level of 0 dBmV, the isolation between subscribers is just at the Part 76 minimum allowable (18 dB) and the required desired/undesired signal ratio is 55 dB, the LO leakage levels would have to be limited to -37 dBmV. The higher levels in the WGII's suggested performance standard reflect:

A. The relatively low probability that receivers connected to one multi-tap will be simultaneously turned on and tuned to channels exactly seven apart (about a 2% probability for an 80 channel system with equal tuning probabilities).

B. The normally higher specified isolation of multi-taps in use in cable systems (compared with the minimum allowed under the Part 76 rules), coupled with the additional isolation afforded by drop cable losses and the fact that most received channels will have a level in excess of the 0 dBmV minimum. This will typically create an isolation sufficient that a leakage level of -26 dBmV is at or below the threshold of visibility.

C. The fact that receivers will have to typically provide performance substantially in excess of that specified in order to achieve acceptable production yields. Further, LO leakage typically exhibits one or more peaks with average leakage far lower. Thus, while the maximum allowable level from 450-1,002 MHz is not sufficient to prevent theoretical visibility, the relatively narrow frequency band over which it might occur further decreases the probability of interference.

D. Finally, such isolated cases of interference that do occur can be resolved by the installation of an isolating amplifier in the drop line of the offending receiver.

3.23 Given these mitigating factors, combined with the cost of materially reducing LO leakage levels from receivers, WGII suggests that the above levels will achieve the Commission's goal in eliminating the leakage of internally generated signals as a source of complaints in the most cost-effective manner.

3.24 ***B. DPU Signals Appearing at Input Terminals.***

3.25 Suggested Performance Standard. The signal level measured at the terminated input terminal of the subscriber equipment shall be less than - 26 dBmV when operated in an external ambient radio frequency field whose frequency varies between 54 and 1,002 MHz and whose field strength is 100 mV/m.

3.26 Discussion: As discussed above, WGII feels that typical performance of multi-port taps combined with the loss of the interconnecting drop cables results in sufficient isolation between customers that leakage levels of -26 dBmV will typically be at or below the threshold of visibility. Also, as with DPU shielding for ingress protection, receiver manufacturers will have to provide substantially better shielding on average in order to achieve 95% conformance in production of product.

3.27 ***Paragraph 23: Image Rejection.*** The NPRM suggests that receivers which are sufficiently shielded to meet DPU requirements will also meet image rejection requirements for interference-free rejection. WGII respectfully disagrees.

3.28 Suggested Performance Standard. Receivers whose conversion frequencies are such that a potential image frequency[2] falls within the cable system bandwidth must reject the image signal by at least the amount in the following table:

Frequency Range	Minimum Rejection
From 54 MHz up to and including 650 MHz	60 dB
From 650 MHz up to and including 1,002 MHz	50 dB

3.29 Discussion. When conventional 45 MHz IF frequencies are utilized in receivers, along with high-side LO injection, the receiver will have a potential response to the 15th higher channel on the system. This response is primarily a function of the internal circuitry design of the receiver, not external shielding efficiency, as both

[2]In heterodyne receivers, the input signal is mixed with a receiver-generated signal (LO) to create an intermediate frequency (IF) for convenience in processing. In such receivers there is a possible response to a second input frequency equal to the sum or difference between the LO and IF frequencies. This is the image frequency.

desired and image channels are received on the same cable. Thus it needs to be separately specified.

3.30 Since the image channel will be offset in frequency from the desired channel, it will appear as a beat. Thus a 55 dB desired/undesired compliance ratio is appropriate to achieve "just perceptible" interference. Unlike some other interference parameters, there is a high probability of the presence of potentially interfering signals for all channels except for the top 15 in use on a given cable system.

3.31 The maximum allowable variation of signal levels under Part 76 is 17 dB in a 1 GHz bandwidth system. If the image were higher than the desired channel by that amount, an isolation of 72 dB would be required. As a practical matter, in a well-maintained cable system, the variation over approximately 90 MHz (15 channels) will be considerably less as the primary form of signal variation in a high-bandwidth system will be a relatively uniform positive or negative slope which is a function of differential cable losses and amplifier operating conditions. The specified isolation will provide 55 dB of desired/undesired ratio for signals which vary by as much as 5 dB for systems utilizing up to approximately 750 MHz for NTSC analog carriers. The relaxed specification at higher frequencies reflects the probability that frequencies above 750 MHz are likely to be used for lower-amplitude digital signals as discussed under Paragraph 22 Tuner Distortion Performance, above.

3.32 ***Paragraph 23 Re-radiation of Cable Signals***. The NPRM proposes to test re-radiation of cable signals from receivers whose input levels are as high as +25 dBmV. The proposed performance limits are those currently specified in the Part 15 rules. WGII respectfully suggests an alternate standard.

3.33 Suggested Performance Standard. The receiver will control re-radiation of cable input signals and products thereof within the limits specified by the FCC for radiation from a cable system[3] when the input to the subscriber's device is any modulated television carrier conforming to one of the channel plans in EIA 542 and whose frequency lies between 54 MHz and 1,002 MHz, and whose visual carrier level at the input terminals of the receiving device is + 15 dBmV or less. If the device is furnished with interconnecting cables, then the leakage will be measured with those cables attached in a normal configuration.

3.34 Discussion. When receivers are connected to cable systems, any radiation of the input signals adds to the incidental radiation from other portions of the cable plant. Individual leaks, whether from the cable plant or from receivers connected to that plant are required to be within the limits set in Part 76, rather than Part 15. While the rules allow cable operators to disconnect service to subscribers whose equipment

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[3]*Code of Federal Regulations*, 47CFR, §76.605(a)(12).

radiates in excess of the limits of Part 76.605(a)(12), WGII felt that a cable ready device should be required to have a shielding effectiveness that prevents such excessive re-radiation. On the other hand, WGII feels that the FCC-suggested cable input signal for the test is excessive. Draft EIA standard IS-23 specifies average signal levels not to exceed +15 dBmV.

3.35 ***Paragraph 24 Switch Isolation: Between Input Ports***. The NPRM reiterates the switch isolation standards currently set by Part 15 of the rules and requests input in suggested standards for the frequencies between the current 550 MHz limit and 1,002 MHz.

3.36 Suggested Performance Standard. A cable compatible subscriber device that incorporates a switching mechanism for selecting between two or more cable system input cables shall, in addition to meeting the isolation requirements of Part 15[4], provide the minimum isolation specified in the table below, as measured between the input ports. The isolation specification between selected and non-selected inputs shall be met with the switch either powered or unpowered. The switching mechanism shall treat the un-selected cable in a manner that complies with the re-radiation requirements of Part 76.605(a)(12).

Frequency Range	Minimum Isolation
From 54 MHz up to and including 216 MHz	80 dB
From 216 MHz up to and including 550 MHz	60 dB
From 550 MHz up to and including 800 MHz	55 dB

3.37 Discussion. The existing Part 15 rules specify the minimum isolation between input ports of antenna selector switches equivalent to the first two specification ranges in the table (80 dB to 216 MHz and 60 dB to 550 MHz). These were deemed necessary to prevent re-radiation of cable signals from subscriber's antennas in excess of the Part 76 requirements, for both individual leaks and cumulative leakage from many subscribers. In a footnote to the Report and Order that established those limits, the Commission noted that the 550 MHz limit was chosen because it represented the highest frequency then in general use by cable operators. Aside from re-radiation of cable signals, the isolation is required to protect other subscribers from signals that may be received from a subscriber's antenna and coupled into the cable system and to protect the user of the receiver from co-channel interference between channels on the two input ports.

3.38 The suggested isolation limit above 550 MHz, combined with the likely maximum cable input signal level of +20 dBmV will limit cable signals fed to subscriber antennas to -35 dBmV. At the same time, subscribers on adjacent tap ports isolated

[4]*Code of Federal Regulations*, 47 CFR, §15.117(h)

APPENDIX D

EIA/NCTA JEC WG-II/2
(Source Document: CATV RF Interface Specification for Television Receiving Devices, Cable Interface Working Group, EIA/NCTA Joint Engineering Committee, October 22, 1985)

DRAFT

RF INTERFACE SPECIFICATION

for

TELEVISION RECEIVING DEVICES

and

CABLE TELEVISION SYSTEMS

January 13, 1994

Developed by
Working Group II
of the
EIA/NCTA Joint Engineering Committee

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1. GENERAL

1.1 Applicability

This specification is intended to apply to all cable systems and to all receiving devices which may be directly connected to a cable system residential outlet, including, but not limited to, television sets, video cassette recorders, and convertors (whether furnished by cable operators or independently acquired by subscribers).

1.2 Existing Federal Specifications

This specification assumes that cable operators comply with all applicable federal regulations, including the performance criteria given in CFR §76.605. To the extent that specific performance levels are given in this document, they are intended to supplement, not replace the existing federal regulations. If conflicts exist between this document and the federal regulations, the stricter of the two will be applicable.

This specification assumes that television receiving devices comply with all applicable federal regulations, including the performance criteria given in CFR §15. To the extent that specific performance levels are given in this document, they are intended to supplement, not replace the existing federal regulations. If conflicts exist between this document and the federal regulations, the stricter of the two will be applicable.

1.3 Compliance Standard

The performance of newly manufactured receivers will vary as a result of normal manufacturing tolerances. Similarly, the performance of cable systems will vary as a function of daily operating variables. In recognition of the difficulty of attaining average performance levels which will assure that every receiver and every cable system will always combine to assure an adequate interface, each parameter in this document are to be met by 95% of receivers and 95% of the time by cable operators. In order to protect customers whose reception is adversely affected by non-conforming equipment or systems, each industry agrees to remedy such problems on an individual basis.

2. MECHANICAL AND ELECTRICAL INTERFACE

2.1 Impedance

Signal interconnection of the cable drop to subscriber receiving devices will utilize shielded coaxial cable at a nominal impedance of 75 ohms.

2.2 Connectors

The cable to the subscriber's device will be furnished with a Type F male connector conforming to Society of Cable Television Engineers specification IPS-SP-401; subscriber's device input will be through a Type F female connector conforming to Society of Cable Television Engineers specification IPS-SP-400.

2.3 Power Line Isolation

Cable systems will insure that the subscriber cable shield (ground) is connected to house ground in accordance with the applicable specifications of the National Electrical Code or local building ordinance, whichever is applicable.

Consumer devices will have UL approved or equivalent power line isolation.

2.4 Surge Protection

Cable systems and TV antennas can deliver high voltage surges to the input of receiving devices, due to lightning or incidental static discharge. Current practice is to protect cable system's hardware and the subscriber's device input circuits against surges, within technology/cost limits. Similar good engineering practice should be applied to any device to be connected to the cable.

3. APPLYING TO THE CABLE SYSTEM: REQUIREMENTS FOR ACCEPTABLE SIGNAL DELIVERY

3.1 Signals Intended for Reception by Cable-Ready Receivers

3.1.1 Levels

The cable television system will provide the following signal level range at the first subscriber device at each outlet.

1. Maximum Individual Visual Carrier Input Level:
10.0 mV across a 75 ohm terminating impedance = + 20 dBmV

2. Maximum Average Visual Carrier Input Level:
5.62 mV across a 75 ohm terminating impedance = + 15 dBmV

3. Minimum Individual NTSC Visual Carrier Input Level:
1.00 mV across a 75 ohm terminating impedance = 0 dBmV

3.1.2 Differential Levels

To reduce visible co-channel interference on a dual cable system, the terminated level differential between equivalent channels shall be within 5 dB .

3.1.3 Frequency Accuracy of Channels on Cable

All NTSC channels, measured at the ground block of the dwelling, shall be within ± 25 kHz of nominal Standard, HRC or IRC frequency assignments (reference EIA 542). When measured after any on-premise signal processing devices furnished and maintained by the cable operator, the frequency shall be within ± 250 kHz of nominal.

3.1.4 Video C/N

By June 30, 1995, the video carrier-to-noise ratio, as defined in Part 76 of the FCC's rules and measured at the dwelling ground block, shall be at least 44 dB.

3.2 Amplitude of Other Carriers Delivered to Input of Cable-Ready Receivers

3.2.1 Maximum Individual Carrier Amplitude

The maximum rms value of the peak level of any individual non-video signal whose frequency exceeds 42 MHz (including the range greater than 1,000 MHz) shall be less than 10.0 mV across a 75 ohm terminating impedance (+20 dBmV).

The maximum rms value of the peak level of any individual non-video signalr whose frequency is between 0.5 and 30 MHz shall not exceed -7 dBm (+42 dBmV).

The maximum rms value of the peak level of any individual non-video carrier whose frequency is between 30 MHz and 42 MHz is currently under consideration. Cable systems are planning on expanding the up-stream bandwidth of systems into this range, however existing receivers do not have a specified tolerance to upstream signals which may be reflected into tuners.

3.2.1 Maximum Average Power Density

The average of the maximum rms value of the peak levels of non-video signals in each 6 MHz bandwidth whose frequencies exceed 42 MHz shall be less than +15 dBmV.

3.3 Digital Transmission Standards

[Space reserved for cable transmission characteristics which may be required to assure an adequate interface to cable-ready receivers when di

INTERMEDIA PARTNERS

David J. Large
Director of Engineering

January 14, 1994

TO: JEC WGII Members

FROM: Dave Large

SUBJECT: FINAL NPRM RESPONSE FILING

Attached is the final text of our response to the current NPRM. It differs from the previous draft in two important areas as a result of rejection by CE at the C^{3}AG level:

- Although we decided in committee to respond only to the specific areas raised in the NPRM, CE felt that some recognition was needed of the negotiated obligations of cable under draft IS-23. Cable was unwilling to re-open Part 76 as that is beyond the scope of the NPRM and Section 17 of the Cable Act. The compromise hammered out Friday between George Hanover and various cable people was to point out to the Commission the existance of IS-23 as a draft voluntary standard, but not to request that Part 76 be reopened.

- The original NPRM response (and IS-23 draft) call for applying the technical standards to converters, as well as TVs and VCRs. There is no dispute about the desirability or logic of this. CE was concerned that the language in the NPRM response could be used by others as a wedge by independent filers to extend the cable-ready requirements to all television receivers. In the end it was decided to delete that paragraph conditioned upon it being satisfactorily dealt with in the C^{3}AG. At the conclusion of our negotiations Friday, two draft additions to the parent group's filing had been composed. George will submit those to the CE caucus to see which is more acceptable.

Other changes were relatively minor:

- The document was numbered for C^{3}AG's convenience in referring to it.

- The CT Jones DPU test procedure was referred to by its original title. Several other references to CableLabs and CT Jones were deleted.

- Reference to tuning range was eliminated as that has become part of the parent group filing.

- Both the Stern and Cohen DPU studies will be included as attachments. Since we refer to the CT Jones test procedure in the text, it will be sent to C^{3}AG who will decide whether to include it as a further attachement.

I think that's all of them. It is being circulated as a formality to our group, but given that language has been carefully worked out in the sensitive areas and there is already agreement on the numbers, it is a little late to make any changes. If you find something really troubling let George or Leroy know on the CE side or Walt or me know on the cable side as any further changes will have to be hammered out in the final C^3AG drafting process.

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January 13, 1994

TO: Chairmen, EIA/NCTA Joint Engineering Committee
Reviewers of the Draft Interface Specification

FROM: Joint Engineering Committee, Working Group II Members

SUBJECT: SUGGESTED PERFORMANCE CRITERIA FOR CABLE-READY RECEIVERS

1.0 INTRODUCTION

1.1 Many of the performance requirements for cable television systems are specified in Part 76 of the FCC's rules. Similarly, many of the performance requirements for television receiving devices are specified in Part 15. These existing rules, however, are not sufficient to assure full compatibility when receiving devices are directly connected to cable system outlets.

1.2 Under the Cable Act of 1992 (the "Act"), the FCC has been mandated to specify the characteristics of receiving devices marketed as "cable ready" (or similar terms) which will assure compatibility. Acting in response to the FCC's call for industry input, the Cable-Consumer Electronics Compatibility Advisory Group ("C^3AG") has requested that the Joint Engineering Committee (JEC) develop technical specifications covering channelization, tuner performance requirements and a decoder interface connector. Working Group II ("WGII") was requested to develop the tuner performance specification. This document is issued in response to the specific tuner performance criteria suggested in the NPRM on consumer criteria.

1.3 In addition, WGII is developing a voluntary standard (identified as EIA IS-23) entitled *RF Interface Specification for Television Receiving Devices and Cable Television Systems*. This document covers additional issues for receivers as well as requirements to be applied to cable operators. While this document is not complete, agreement has been reached on many parameters of the interface.

2.0 GENERAL COMMENTS

2.1 ***Approach.*** While it is possible to develop specifications which will assure interference-free reception in every case, including combinations of worst-case situations, it would result in cable systems and receivers whose performance is far in excess of that required for most conditions and excessive costs which will ultimately have to be borne by consumers. WGII determined that it was more cost effective to achieve performance levels that would assure compatibility in the vast majority of cases and to leave it to manufacturers and operators to deal with the few individual cases in which unusual combinations of performance and operating conditions cause reception problems.

2.2 In keeping with that philosophy, WGII recognizes that the performance of manufactured receivers will vary. In order to avoid the degree of over- specification that would be required to assure 100% compliance with every specification, we feel that a 95% compliance level with each specification is more cost effective and strongly suggest that the FCC adopt this standard with respect to the performance criteria under consideration. We wish to emphasize that this is not an attempt to modify compliance levels with existing Part 15 or Part 76 rules, but rather that this compliance standard will apply only to the suggested new performance criteria suggested in the NPRM.

2.3 ***Remaining Efforts to Complete.*** In response to the NPRM, this document suggests performance levels for most of the parameters listed. The work remaining to completely specify the interface includes:

- Complete Test Procedures. WGII has several proposed test procedures under review. It will be some time before these can be thoroughly evaluated and incorporated into the document.

- Tuner Characteristics Required for Digitally Compressed Signals. The proposed Decoder Interface Connector includes an unfiltered IF output port. This output is required for full compatibility with all existing analog scrambling systems and also offers the possibility of introducing digitally-compressed programming without immediately re-creating the necessity of using a set-top descrambler. Unfortunately, digital transmission formats are still being developed and thus it is not yet possible to specify with certainty the unique tuner performance characteristics required to pass the digital signal to the IF output with adequate fidelity to assure reasonably error-free reception by a set-back decoder. A working party of the Decoder Interface Working Group is actively gathering data from digital transmission proponents in order to guide us in this area and we hope to be able to provide guidance to receiver manufacturers in time for incorporation in cable-ready receivers.

3.0 RESPONSE TO SPECIFIC NPRM TUNER PERFORMANCE SPECIFICATIONS

3.1 The following comments are referenced to paragraph numbers in the NPRM. Where reference is made in the following response to visual signal level, that level is understood to be defined as it is in the Part 76 rules, *i.e.* the rms value of the visual carrier measured during the synchronizing pulse.

3.2 ***Paragraph 22: Adjacent Channel Rejection.*** The NPRM suggests requiring receivers to not exceed the "just perceptible" interference level when the input consists of a desired signal and adjacent signals whose levels exceed the desired channel by 3 dB. This channel level difference is consistent with Part 76 requirements on cable operators. WGII agrees with this suggested standard.

3.3 Suggested performance standard: When the input to a receiver consists of an NTSC channel whose visual signal level is between 0 and +20 dBmV, plus an additional unmodulated carrier whose frequency is 1.5 MHz ± 50 kHz lower in frequency than

the visual carrier of the NTSC channel and whose level is 10 dB below the visual signal level of the NTSC channel, the level of the spurious response 1.5 MHz above the visual carrier, as measured at the unfiltered IF output port, shall be at least 55 dB below the level of the NTSC channel visual signal.

3.4 Discussion: Adjacent channel performance is the combined response to lower and upper adjacent visual, chroma and aural signals. In accordance with Part 76, the aural signal levels of those adjacent channels may vary in level from -10 dB to -17 dB with respect their visual signals, though in practice, few operators use levels in excess of -13 dB. Industry experience suggests that lower adjacent aural signal interference dominates the other potential sources and therefore WGII has limited the test to that single parameter. Although it is possible that the visual signal of a lower adjacent channel could be as much as 3 dB higher (the maximum Part 76 allowable adjacent channel level difference) and simultaneously have its aural carrier set as high as -10 dB with respect to its visual signal, WGII feels that a lower adjacent aural level of -10 dB will seldom be exceeded in actual installations.

3.5 The visual appearance of lower adjacent aural interference is in the form of a 1.5 MHz beat pattern in the desired channel picture. As such, its appearance is similar to other discrete interfering carriers and a 55 dB suppression ratio is appropriate.

3.6 ***Paragraph 22: Tuner Distortion Products***. The NPRM suggests that tuners not generate distortion products exceeding 55 dB below visual carrier levels.

3.7 Suggested Performance Standard. When the input to a receiver consists of a comb of unmodulated carriers whose frequencies correspond to all of the possible video carriers between 54 and 750 MHz, in the Standard (as opposed to HRC or IRC) frequency plans delineated in EIA 542, and whose individual amplitudes are +15 dBmV, the magnitude of all spurious products falling within the 6 MHz wide unfiltered IF shall be at least 51 dB below the amplitude of any tuned carrier.

3.8 Discussion. Tuner overload performance is a measure of the magnitude of intermodulation products which lie within the tuned channel. When receivers are connected to cable systems, they are exposed to the entire spectrum of signals carried, as opposed to the off-air situation where many fewer signals are present (though generally of more widely varying amplitudes). WGII suggests standardizing on a test signal condition which corresponds to the maximum amplitude comb of cable signals likely to impinge upon receiver tuners connected to a cable drop cable (but using CW carriers in place of modulated television signals for all but the channel under test) and extending from 54 to 750 MHz.

3.9 Part 76 of the Commission's rules do not specify a maximum cable-delivered visual signal level at the input of subscriber's equipment. Draft EIA Standard IS-23 contains limits on the maximum amplitude of individual visual signals (+20 dBmV), on the average visual signal level (+15 dBmV), and the peak and average amplitudes of non-video signals which may be present at the receiver input terminals. WGII's suggested test signal condition for receivers is consistent with this standard.

3.10 We feel that limiting the spectrum to 750 MHz, rather than 1,002 MHz is justified because:

- It is more probable that digital, rather than analog signals will be used at these higher frequencies and that a) they are likely to be lower in level by at least 5-10 dB and b) due to their broader spectral spread, their effect visual effect is more like a slight increase in noise than a discrete beat.

- If analog signals are used, it is more likely that higher frequencies will be attenuated relative to lower frequencies due to the differential loss in the drop cable.

3.11 Under these conditions we recommend that the limit for all products falling within the 6 MHz IF passband be set to -51 dB with respect to the level of the desired visual signal during synchronizing pulses. Although this is higher than the -55 dB standard suggested in the NPRM, it should be understood that, in normal operation, the IM products will meet the NPRM-suggested performance standard because normal NTSC television signals have about 6 dB lower average power levels than the CW test carriers. The use of CW carriers for IM testing is universally used in transmission equipment because it gives repeatable results.

3.12 ***Paragraph 23: DPU.*** The NPRM suggests that a receiver exposed to a 100 mV/m external RF field not exceed the standard of "just perceptible" ingress interference to the received signal.

3.13 Suggested Performance Standard: The average of the subscriber device's response to exposure to an external ambient radio frequency field whose frequency varies between 54 and 800 MHz and whose amplitude is 100 mV/m, when tuned to each of six EIA 542 television channels (two each in the low VHF, high VHF and UHF broadcast bands) whose individual RF levels are 0 dBmV, shall be 50 dB below the response to the desired signal (90 dB REL[1]). Additionally, the response at any individual channel shall not exceed 45 dB below the response to the desired signal. At frequencies between 800 MHz and 1,002 MHz, the average response when tuned to six EIA 542 channels approximately equally spaced in the band shall be 40 dB below the response to the desired signal (80 dB REL) and at no individual channel shall the response exceed 35 dB below the response to the desired signal. Response shall be measured by the relative level of the desired signal visual signal (measured during the synchronizing pulse) and the rms amplitude of the interfering carrier as measured

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[1]Receiver Effective Length (REL) is a commonly used measurement of shielding efficiency which can be mathematically expressed as:

$$REL = D/U(dB) + FS(dBmV/m) - RCV(dBmV)$$

Where: D/U = ratio of desired visual signal level to interfering carrier in dB
FS = external field strength in dB relative to 1 mV/m
RCV = the level of the desired signal in dBmV

within the 6 MHz nominal bandwidth of the channel at the unfiltered IF output port. If the device is furnished with interconnecting cables, then the measurement shall be made with the interconnecting cables attached in a normal configuration. The measurement method shall be equivalent to that developed by Carl T. Jones and entitled *Susceptibility Test Methodology and Test Procedures for Television Receivers and Video Cassette Receivers*, with such modifications as mutually agreed upon by the consumer electronics and cable television industries.

3.14 Discussion. A study done by Stern, under CableLabs sponsorship, predicts that 40.8% of television households will experience field strengths of 100 mV/m or greater on at least one television broadcast channel. A similar study done on behalf of the EIA by Jules Cohen predicts that 46.2% of households will experience 100 mV/m. Above that field strength, the studies diverge, with Stern predicting that 6% will experience field strengths of 1 volt/m, while Cohen predicts 8.4% will experience 300 mV/m, but less than 1% will experience 1V/m. Both studies predict that the probability of UHF interference exceeds that of VHF interference at the highest field strengths which is unfortunate from the standpoint of visual impairment as UHF stations are offset from cable channels in the same frequency ranges resulting in beat patterns which are subjectively more apparent than frequency coherent interference. Neither study included interference from non-television-broadcast sources such as paging transmitters. Both studies are included with this document.

3.15 There are, however, mitigating factors. For one thing, the C.T.Jones test procedure currently under review measures susceptibility at all receiver orientations relative to the external field. Testing of 35 representative television receivers (plus a number of VCRs and converters) done by Jones suggests that susceptibility is strongly dependent on this orientation. Given that actual receivers may be oriented randomly with respect to external fields, the average susceptibility in homes will certainly be less than the tested maximum. Secondly, neither study attempted to predict the average effects of buildings and other structures on the signal strength received by receivers inside dwellings relative to that measured in relatively "free space" outside. While in some cases, the field strengths may actually be higher due to reflected signals constructively combining or due to receivers being located far above ground level (as in a high-rise apartment situation), on average it can be expected that there will be some attenuation affects.

3.16 Finally, the existing Canadian standard is 80 dB REL over a more limited frequency range, so that the proposed standard represents a material improvement over current practice.

3.17 Given the mitigating factors, WGII believes that its proposed standard is consistent with the Commission's proposed performance criteria. We further submit that the test procedure used has the advantage that it does not rely on subjective observation of picture impairment

3.18 ***Paragraph 23: Emissions Conducted Into Cable Systems From Receivers***. The Commission has suggested limiting the amplitude of all signals transmitted by receivers back into cable systems to -37 dBmV.

3.19 Emissions into cable systems from television receiving devices can originate from one of three sources:

A. Local oscillator and other internally generated signals in the television receiver.

B. DPU signals.

C. Signals from consumer's off-air antennas coupled through the limited isolation between the input terminals of input selector switches (covered under Paragraph 24, below).

3.20 ***A. Local Oscillator and Other Signals Appearing at Input Terminals***.

3.21 Suggested Performance Standard: The level of any local oscillator and of any other signal of an undesired or spurious nature generated within a subscriber's device to be connected to the cable and arriving at the cable input terminal of the device shall not exceed the values in the following table:

Frequency Range	Maximum Allowable Level	Average Allowable Level*
Above 54 MHz up to and including 300 MHz	-26 dBmV	n/a
Above 300 Mhz up to and including 450 MHz	-20 dBmV	n/a
Above 450 MHz up to and including 1,002 MHz	-15 dBmV	-20 dBmV

*Averaged from measurements on six channels spaced approximately equally in frequency.

3.22 Discussion: With conventional 45 MHz intermediate frequencies (IF), the local oscillator (LO) of a receiver will fall within the passband of another television channel. Given the finite isolation between subscribers connected to multi-taps on cable systems, if that LO signal is transmitted out of the input terminals of one receiver with sufficient amplitude it will interfere with the reception of a subscriber connected to another tap port and tuned to a program seven channels above the interfering receiver. In the worst case situation in which a desired channel is received at the Part 76 minimum allowable level of 0 dBmV, the isolation between subscribers is just at the Part 76 minimum allowable (18 dB) and the required desired/undesired signal ratio is 55 dB, the LO leakage levels would have to be limited to -37 dBmV. The higher levels in the WGII's suggested performance standard reflect:

A. The relatively low probability that receivers connected to one multi-tap will be simultaneously turned on and tuned to channels exactly seven apart (about a 2% probability for an 80 channel system with equal tuning probabilities).

B. The normally higher specified isolation of multi-taps in use in cable systems (compared with the minimum allowed under the Part 76 rules), coupled with the additional isolation afforded by drop cable losses and the fact that most received channels will have a level in excess of the 0 dBmV minimum. This will typically create an isolation sufficient that a leakage level of -26 dBmV is at or below the threshold of visibility.

C. The fact that receivers will have to typically provide performance substantially in excess of that specified in order to achieve acceptable production yields. Further, LO leakage typically exhibits one or more peaks with average leakage far lower. Thus, while the maximum allowable level from 450-1,002 MHz is not sufficient to prevent theoretical visibility, the relatively narrow frequency band over which it might occur further decreases the probability of interference.

D. Finally, such isolated cases of interference that do occur can be resolved by the installation of an isolating amplifier in the drop line of the offending receiver.

3.23 Given these mitigating factors, combined with the cost of materially reducing LO leakage levels from receivers, WGII suggests that the above levels will achieve the Commission's goal in eliminating the leakage of internally generated signals as a source of complaints in the most cost-effective manner.

3.24 ***B. DPU Signals Appearing at Input Terminals.***

3.25 Suggested Performance Standard. The signal level measured at the terminated input terminal of the subscriber equipment shall be less than - 26 dBmV when operated in an external ambient radio frequency field whose frequency varies between 54 and 1,002 MHz and whose field strength is 100 mV/m.

3.26 Discussion: As discussed above, WGII feels that typical performance of multi-port taps combined with the loss of the interconnecting drop cables results in sufficient isolation between customers that leakage levels of -26 dBmV will typically be at or below the threshold of visibility. Also, as with DPU shielding for ingress protection, receiver manufacturers will have to provide substantially better shielding on average in order to achieve 95% conformance in production of product.

3.27 ***Paragraph 23: Image Rejection.*** The NPRM suggests that receivers which are sufficiently shielded to meet DPU requirements will also meet image rejection

3.28 Suggested Performance Standard. Receivers whose conversion frequencies are such that a potential image frequency[2] falls within the cable system bandwidth must reject the image signal by at least the amount in the following table:

Frequency Range	Minimum Rejection
From 54 MHz up to and including 650 MHz	60 dB
From 650 MHz up to and including 1,002 MHz	50 dB

3.29 Discussion. When conventional 45 MHz IF frequencies are utilized in receivers, along with high-side LO injection, the receiver will have a potential response to the 15th higher channel on the system. This response is primarily a function of the internal circuitry design of the receiver, not external shielding efficiency, as both desired and image channels are received on the same cable. Thus it needs to be separately specified.

3.30 Since the image channel will be offset in frequency from the desired channel, it will appear as a beat. Thus a 55 dB desired/undesired compliance ratio is appropriate to achieve "just perceptible" interference. Unlike some other interference parameters, there is a high probability of the presence of potentially interfering signals for all channels except for the top 15 in use on a given cable system.

3.31 The maximum allowable variation of signal levels under Part 76 is 17 dB in a 1 GHz bandwidth system. If the image were higher than the desired channel by that amount, an isolation of 72 dB would be required. As a practical matter, in a well-maintained cable system, the variation over approximately 90 MHz (15 channels) will be considerably less as the primary form of signal variation in a high-bandwidth system will be a relatively uniform positive or negative slope which is a function of differential cable losses and amplifier operating conditions. The specified isolation will provide 55 dB of desired/undesired ratio for signals which vary by as much as 5 dB for systems utilizing up to approximately 750 MHz for NTSC analog carriers. The relaxed specification at higher frequencies reflects the probability that frequencies above 750 MHz are likely to be used for lower-amplitude digital signals as discussed under Paragraph 22 Tuner Distortion Performance, above.

3.32 ***Paragraph 23 Re-radiation of Cable Signals***. The NPRM proposes to test re-radiation of cable signals from receivers whose input levels are as high as +25 dBmV. The proposed performance limits are those currently specified in the Part 15 rules. WGII respectfully suggests an alternate standard.

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[2]In heterodyne receivers, the input signal is mixed with a receiver-generated signal (LO) to create an intermediate frequency (IF) for convenience in processing. In such receivers there is a possible response to a second input frequency equal to the sum or difference between the LO and IF frequencies. This is the image frequency.

3.33 Suggested Performance Standard. The receiver will control re-radiation of cable input signals and products thereof within the limits specified by the FCC for radiation from a cable system[3] when the input to the subscriber's device is any modulated television carrier conforming to one of the channel plans in EIA 542 and whose frequency lies between 54 MHz and 1,002 MHz, and whose visual carrier level at the input terminals of the receiving device is + 15 dBmV or less. If the device is furnished with interconnecting cables, then the leakage will be measured with those cables attached in a normal configuration.

3.34 Discussion. When receivers are connected to cable systems, any radiation of the input signals adds to the incidental radiation from other portions of the cable plant. Individual leaks, whether from the cable plant or from receivers connected to that plant are required to be within the limits set in Part 76, rather than Part 15. While the rules allow cable operators to disconnect service to subscribers whose equipment radiates in excess of the limits of Part 76.605(a)(12), WGII felt that a cable ready device should be required to have a shielding effectiveness that prevents such excessive re-radiation. On the other hand, WGII feels that the FCC-suggested cable input signal for the test is excessive. Draft EIA standard IS-23 specifies average signal levels not to exceed +15 dBmV.

3.35 ***Paragraph 24 Switch Isolation: Between Input Ports***. The NPRM reiterates the switch isolation standards currently set by Part 15 of the rules and requests input in suggested standards for the frequencies between the current 550 MHz limit and 1,002 MHz.

3.36 Suggested Performance Standard. A cable compatible subscriber device that incorporates a switching mechanism for selecting between two or more cable system input cables shall, in addition to meeting the isolation requirements of Part 15[4], provide the minimum isolation specified in the table below, as measured between the input ports. The isolation specification between selected and non-selected inputs shall be met with the switch either powered or unpowered. The switching mechanism shall treat the un-selected cable in a manner that complies with the re-radiation requirements of Part 76.605(a)(12).

Frequency Range	Minimum Isolation
From 54 MHz up to and including 216 MHz	80 dB
From 216 MHz up to and including 550 MHz	60 dB
From 550 MHz up to and including 800 MHz	55 dB

[3]*Code of Federal Regulations*, 47CFR, §76.605(a)(12).

[4]*Code of Federal Regulations*, 47 CFR, §15.117(h)

3.37 Discussion. The existing Part 15 rules specify the minimum isolation between input ports of antenna selector switches equivalent to the first two specification ranges in the table (80 dB to 216 MHz and 60 dB to 550 MHz). These were deemed necessary to prevent re-radiation of cable signals from subscriber's antennas in excess of the Part 76 requirements, for both individual leaks and cumulative leakage from many subscribers. In a footnote to the Report and Order that established those limits, the Commission noted that the 550 MHz limit was chosen because it represented the highest frequency then in general use by cable operators. Aside from re-radiation of cable signals, the isolation is required to protect other subscribers from signals that may be received from a subscriber's antenna and coupled into the cable system and to protect the user of the receiver from co-channel interference between channels on the two input ports.

3.38 The suggested isolation limit above 550 MHz, combined with the likely maximum cable input signal level of +20 dBmV will limit cable signals fed to subscriber antennas to -35 dBmV. At the same time, subscribers on adjacent tap ports isolated by at least 20 dB will not be subject to significant interference (<55 dB desired/undesired signal ratio) with antenna input levels up to +20 dBmV through the UHF broadcast band. While switch isolation can be expected to deteriorate smoothly above 800 MHz, the strength of interfering carriers is also expected to be less and typical antenna gain will also be less outside of the designed reception frequency range.

3.39 While paragraph 24 addresses the effects of limited switch isolation on re-radiation of cable signals and on ingress to cable systems affecting other receivers, this specification also has an effect on the user of the receiver which has the switch, since limited isolation between input ports also allows signal leakage from the non-selected input source to interfere with the selected input signals. The principal situation leading to potential interference occurs when one input is connected to the cable system and the other to an external antenna. The effect is exactly the same as DPU. The specified isolations are sufficient to provide 55 dB desired/undesired protection for input signals differing by 25 dB through the VHF broadcast band, 5 dB through 550 MHz and matched level signals through the UHF band.

3.40 Another possible use of antenna selector switches is to switch between the two cables of a dual cable system. To minimize the chance of a level unbalance between the signals on the two cables leading to interference, Draft EIA Standard IS-23 requires that the levels of equivalent channels on the two cables be matched within 5 dB.

3.41 ***Paragraph 25 Signal Loss in Cascaded Equipment***. The NPRM suggests that equipment which includes a bypass function or which is used to bypass converters or other equipment have a maximum loss at any output port of 6 dB.

3.42 Suggested Performance Standard. In order to assure adequate signal strength to the second of two cascaded subscriber devices, the first shall cause a signal drop no greater than that specified in the table below:

Frequency Range	Maximum Loss
From 54 MHz up to and including 550 MHz	6 dB
From 550 MHz up to and including 1,002 MHz	8 dB

3.43 Discussion. Typically devices used to bypass other equipment or which include bypass circuitry as part of its internal design will include at least one signal splitter. While the ideal loss of an equal splitter is 3 dB, component losses plus cabling and possibly switching losses will increase that, particularly at the higher frequencies. The limits suggested are intended to insure that receivers which include splitting devices which siphon off a portion of the input signal for internal use (such as VCRs) do not favor their internal tuner by using unequal split ratios and thus cause following receivers to suffer unduly low signal levels. While WGII expects that receiver manufacturers will typically achieve losses better than the specification by 1-2 dB, the limits reflect unavoidable manufacturing variations.